



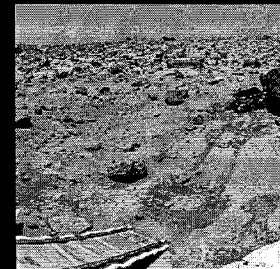
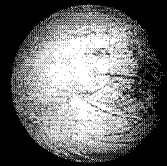
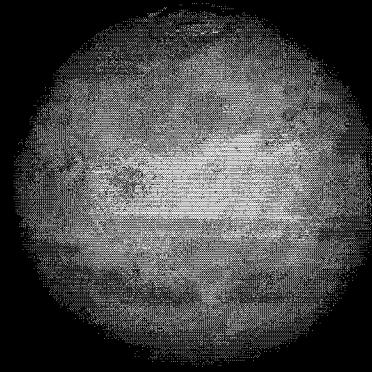
Future Missions Concepts for The Exploration of the Solar System

**By Erik N. Nilsen
Manager, Advanced Mission Studies Office
Jet Propulsion Laboratory**

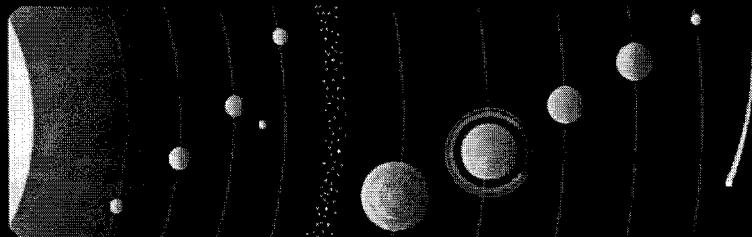
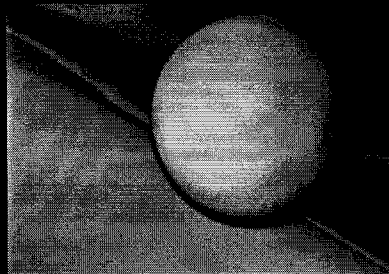
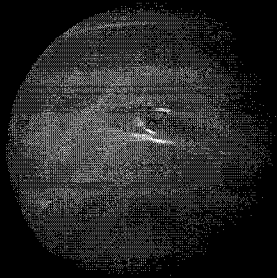
**A Presentation to the Bio-Inspired Engineering of Exploration Systems 2000
Workshop
December 4-6, 2000
Jet Propulsion Laboratory**

Solar System Exploration Programs

**Mars Exploration Program:
Bringing Mars to Earth**

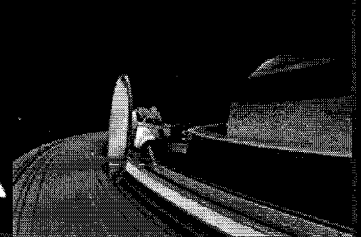
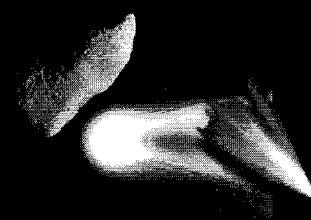


**Outer Planets Program:
Exploring Organic-Rich Environments**



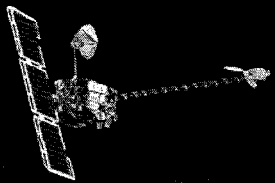
**Discovery Program:
Partnerships for Innovation**

**Proposed New Initiative -To Build a Planet:
Formation and evolution of
planetary environments**



Mars Mission Architecture 2001 - 2011

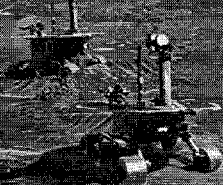
2001



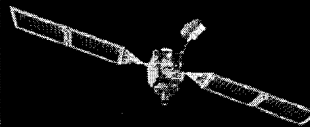
Mars Odyssey

2003

Mars
Exploration
Rovers



2005



Mars Reconnaissance
Orbiter

2007



ASI Telecom



CNES Aerocapture

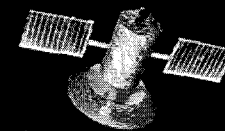


Aerial Scouts



Netlanders

2009



ASI/U.S. SAR

2011

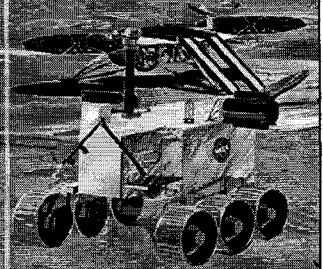
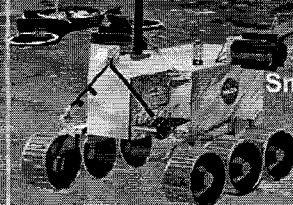


CNES Return

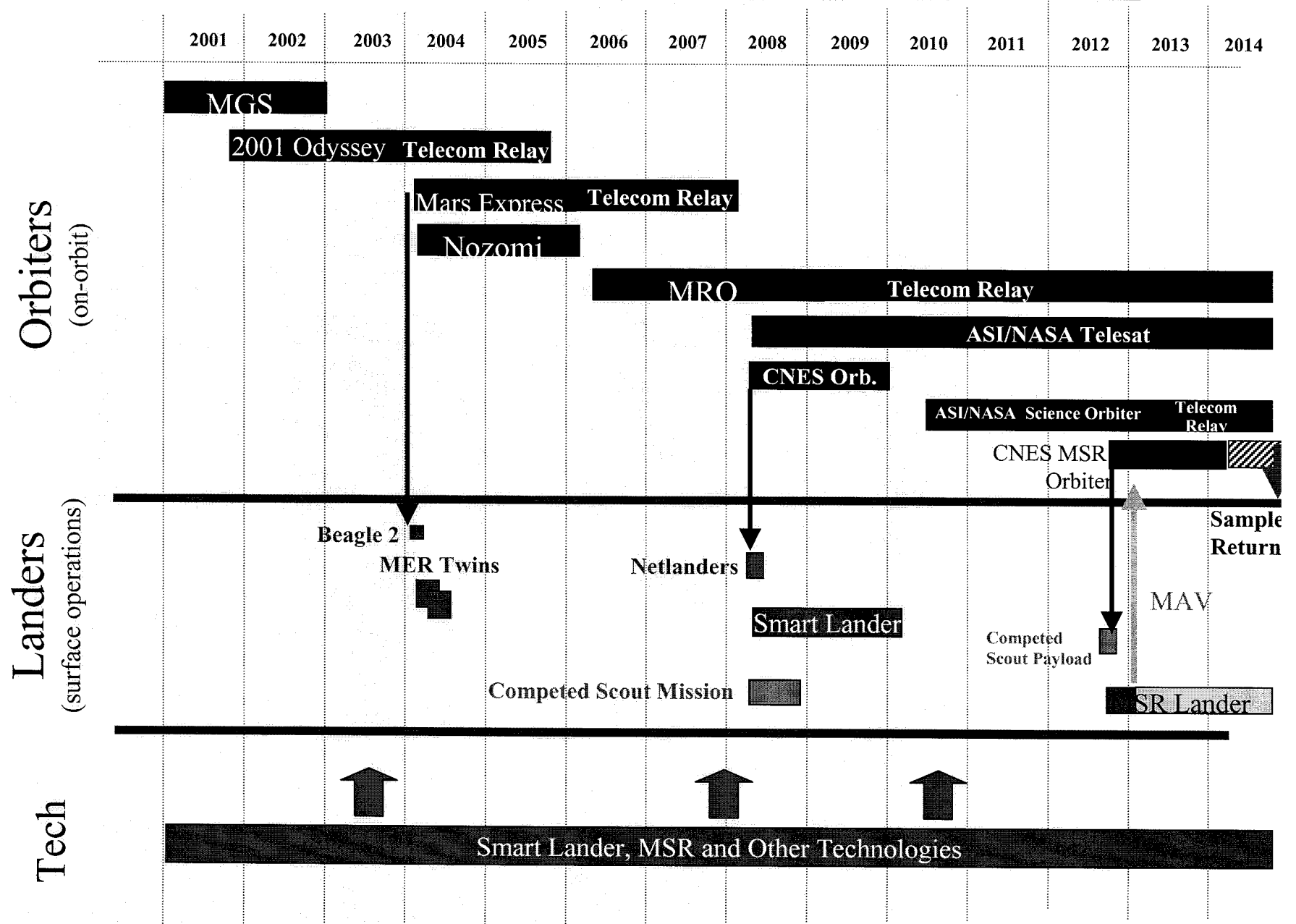


Mars Sample Return
(with Smart Lander & Rover)

Smart Lander
& Rover



Mars Mission Timeline

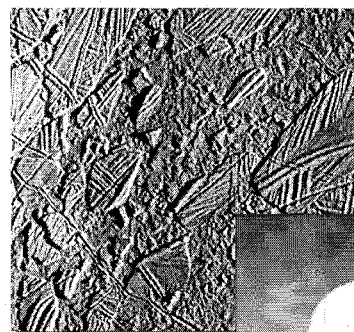




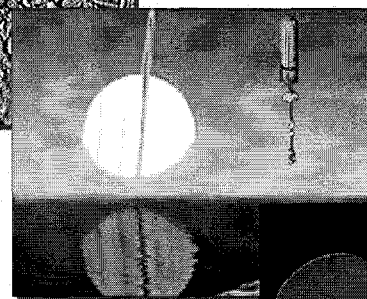
Outer Solar System Exploration



Outer Planets Program: Exploring Organic-Rich Environments

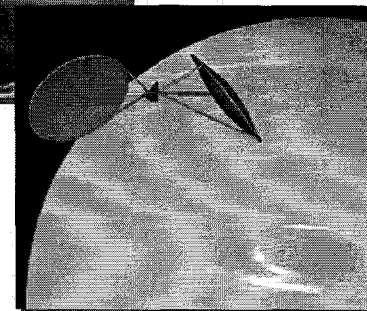
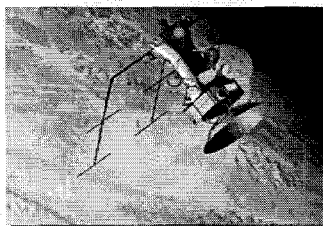


Europa
Lander



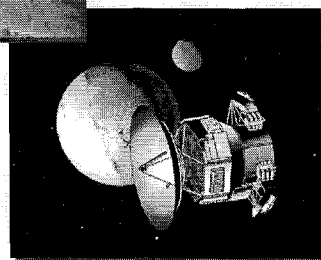
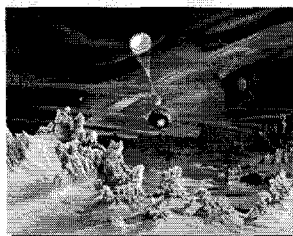
Titan
Explorer

Europa Orbiter



Neptune Orbiter

Cassini/Huygens



Pluto/Kuiper Express

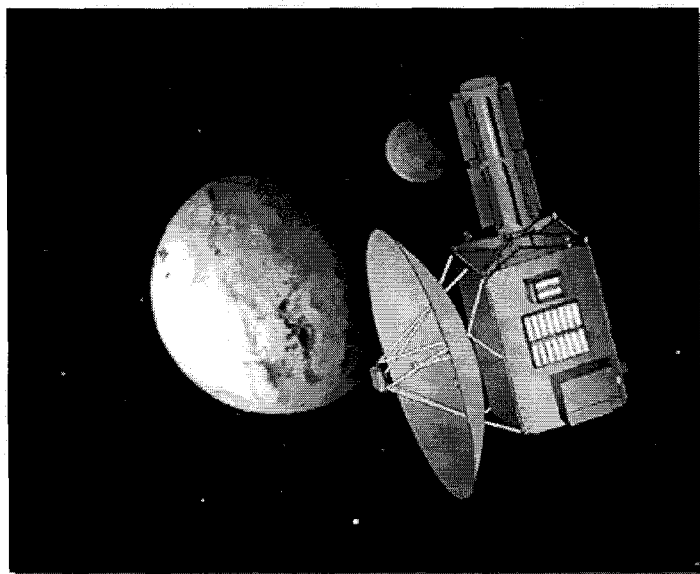
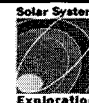


Galileo-Europa





Pluto-Kuiper Express



Objectives:

- Geology of Pluto and Charon
- Maps of surface composition and atmospheric structure
- First images of Kuiper objects

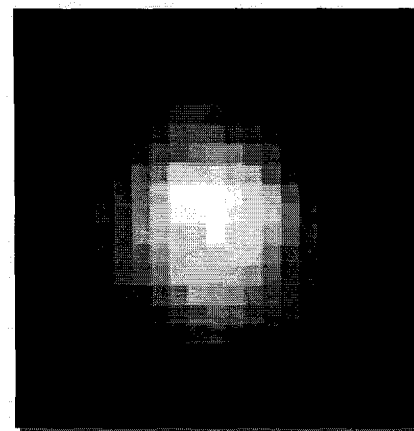
Strawman Investigations

- Imaging
- IR Mapping Spectrometry
- UV Spectrometry
- Radio Science Uplink Occultation

Mission Study Parameters

Trajectory Type	SEP or Gravity Assist
Launch Date	TBD
Arrival Time	<2020
Flight Time	8-10 yrs
Launch System	EELV/Star-48

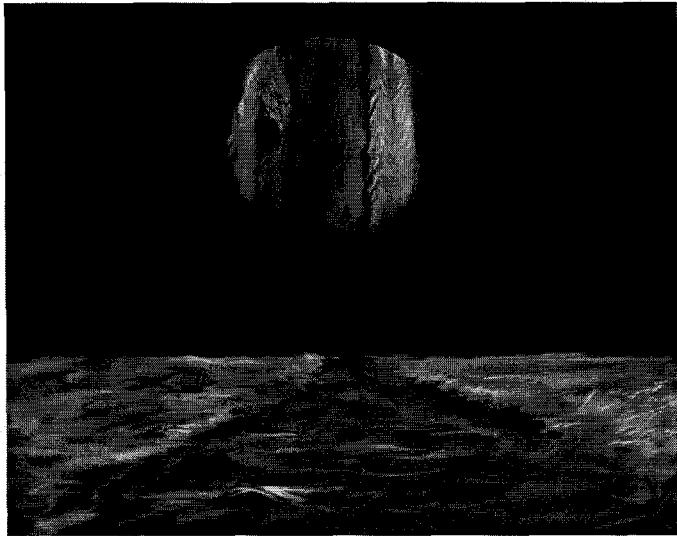
EELV = Evolved Expendable Launch Vehicle



Best image of Pluto to date



Exploring Europa: Beyond Europa Orbiter



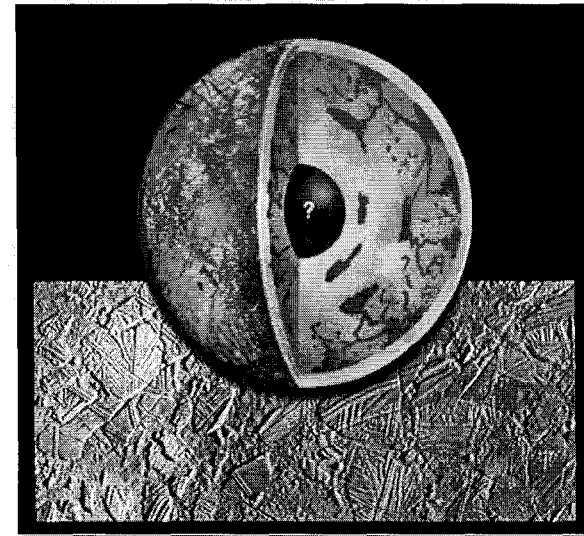
Europa may one day become a target for a comprehensive “Mars-like” exploration program.

- ***Critical Questions***

- What is the age and composition of the Europa surface?
- What organic chemical processes are taking place?
- Is there potential access to liquid water?
- Are there any indications of pre-biological activity?
- Is there life?

- ***Key Capabilities***

- High performance, low mass propulsion for descent
- Autonomous landing and hazard avoidance
- Miniature organic chemistry laboratories
- Sample acquisition & processing
- Bioload reduction
- Radiation tolerant components
- Ice penetration and mobility





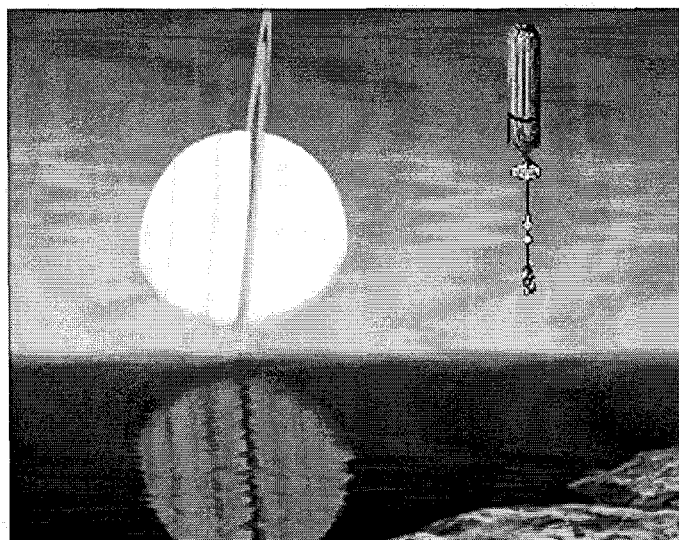
Potential Elements of a Europa Exploration Program

- Europa Orbiter
 - Detect and characterize global water and examine surface ice
- Surface experiments: Science and technology pathfinders
 - Carried by Europa Orbiter?
 - Coordinated with Europa Orbiter?
 - Impactors, penetrators, “Ranger”-like imagers, “Scout” survivable landers
 - Characterize surface, demonstrate capabilities, examine landing sites
- Soft landers and mobile science stations
 - Detailed surface structure and chemistry
- Subsurface exploration: Ice and/or water mobile platforms (“Cryobots”)
 - Detailed subsurface chemistry
 - Search for indicators of prebiotic chemistry or past or present life
- Sample return from the surface or subsurface





Titan Exploration: Beyond Cassini/Huygens



Titan may bridge the gap between life's chemical building blocks and more evolved environments such as Earth and Mars.

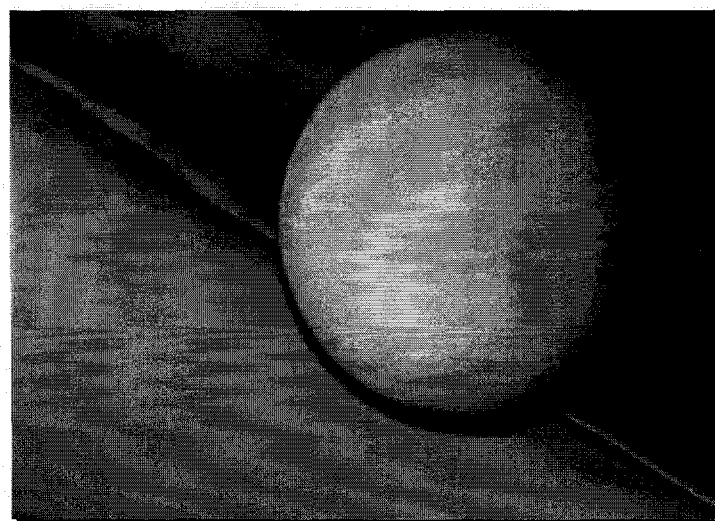
Critical Questions

- What prebiotic chemistry is taking place at Titan and what can it tell us about the primordial Earth...and the origin of life?
- What is the composition of Titan's surface and how does it interact with the atmosphere?
- How has Titan evolved over its history?

- Atmospheric and surface measurements
- Aerial platforms, landers, surface rovers
- Atmosphere and surface sample return

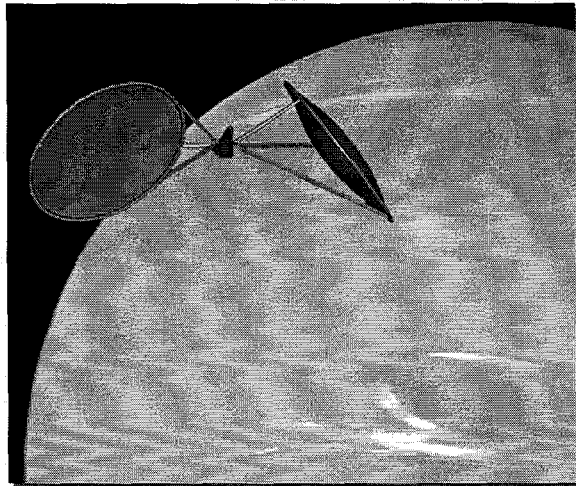
• **Key Capabilities**

- Balloon or aircraft mobility
- Aerocapture at Titan
- Miniature *in situ* chemistry lab
- Sample acquisition
- Bioload reduction
- Advanced propulsion





Neptune Orbiter Mission



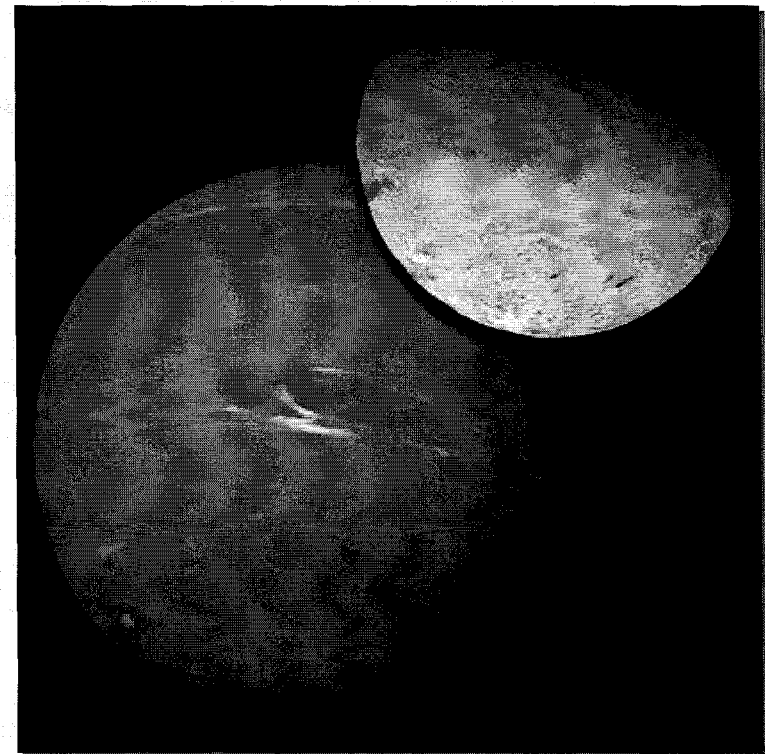
- **Critical Questions**

- What is Neptune's atmospheric structure and chemistry? What is the structure and behavior of its magnetosphere?
- What are Triton's physical properties? Is it a captured Kuiper object? What can it tell us about the formation and evolution of the far outer solar system?
- What are the dynamics of the rings and satellites?

- Ready for mission start: 2006-2007
- 10 year flight to Neptune, 2-4 year orbital tour
- Multiple flybys of Triton and sampling of upper atmosphere

- **Key Capabilities**

- Aerocapture
- Advanced telecommunications system
- High-power solar electric propulsion
- Autonomous spacecraft operations
- Temperature tolerant electronics





Proposed New Initiative: *To Build a Planet*

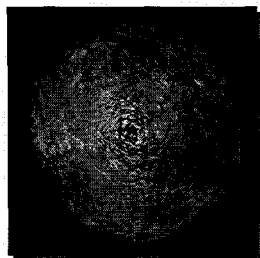


*To Build a Planet:
Formation and evolution
of planetary environments*

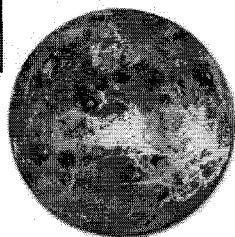
MESSENGER



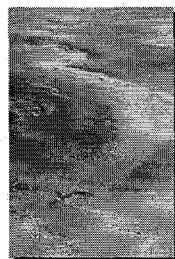
Lunar Prospector



Magellan



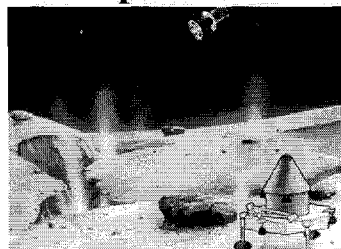
Mars Surveyor



**Primitive
Bodies Missions**



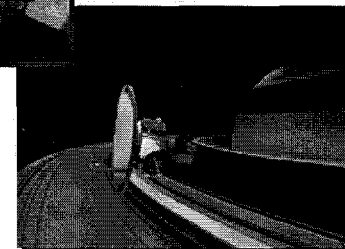
**Comet Nucleus
Sample Return**



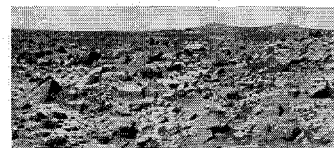
**Venus
Sample Return**



**Saturn Ring
Observer**

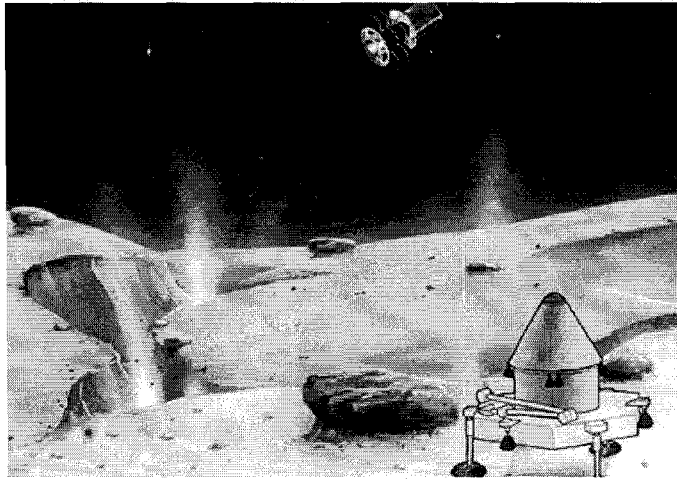


Mars Surveyor





Comet Nucleus Sample Return



- Mission duration 6 to 10 yrs
- Launch opportunities every year
- Solar electric propulsion

• **Key Capabilities**

- Comet sample acquisition and handling
- Improved solar electric propulsion
- Autonomous control and navigation
- Precision guidance and landing
- High-efficiency solar arrays
- High velocity Earth entry system

Critical Questions:

- What is the chemical composition of pristine comet nucleus material? What does it tell us about the primordial solar system?
- How have comets evolved since their formation? How does their composition vary with depth and location on the nucleus?
- What can we learn about the likely effects and mitigation of cometary impacts?

Trade Studies FY00

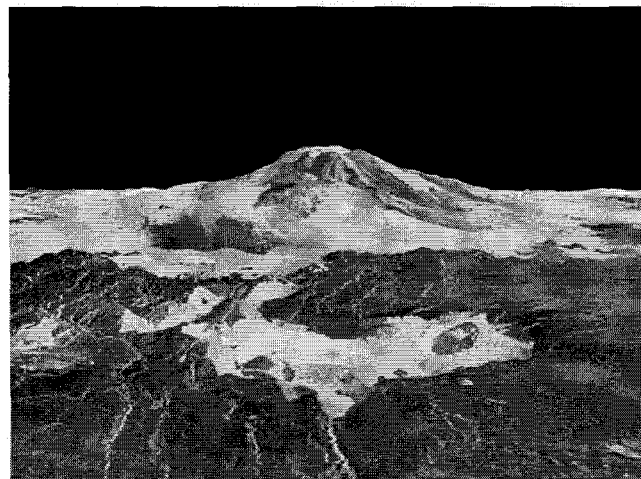
S/C Architecture: Single vs Dual

Mission Design: Full SEP, BiProp
Return, G/A for
sample insertion

Mission Factors: Dust Mitigation
Telecom scenarios
Site Selection



Venus Exploration: Surface Sample Return



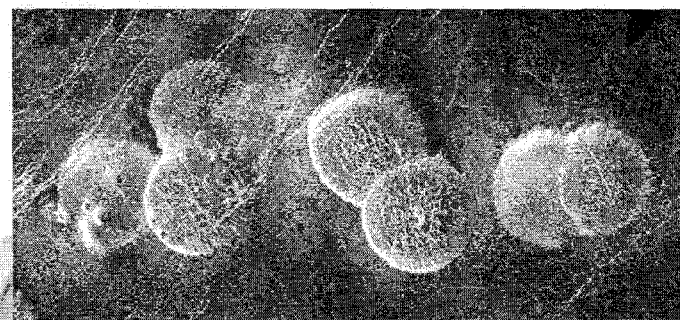
Critical questions

- What is the age and chemical composition of Venus' surface? What is its atmospheric composition?
- Why did Venus and Earth take such different evolutionary pathways?
- Was there ever liquid water on Venus? Where did it go?
- What can Venus tell us about the future of planet Earth?

- Tech readiness possible by 2006-2007
- Short-duration surface stay time (~90 min)
- Balloon/rocket ascent
- Significant use of Mars Sample Return technologies
- Precursor missions likely

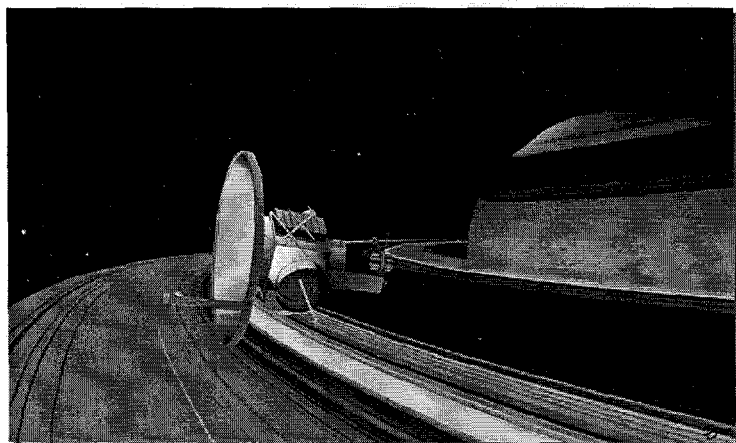
• *Key Capabilities*

- Aerocapture
- High temperature balloon system
- Thermal control
- Sampling mechanisms





Saturn Ring Observer



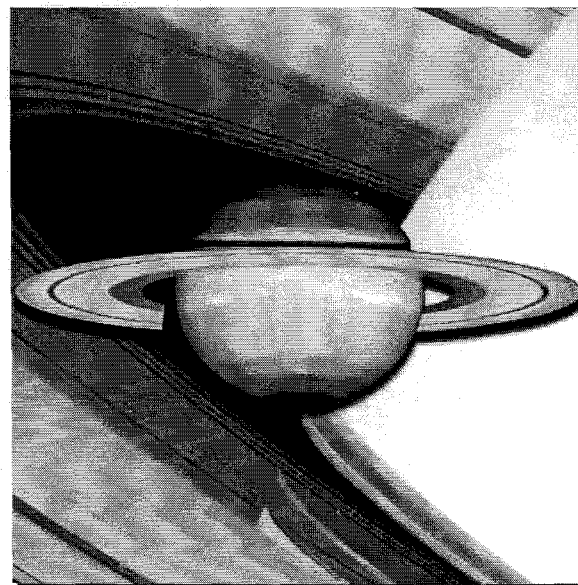
- **Critical Questions**

- What are the physical properties of the icy particles comprising Saturn's rings?
- What do their detailed, time-varying interactions tell us about the evolution of Saturn's rings?
- What does the detailed study of Saturn's rings tell us about the early stages of planet formation and the present-day dynamics of extra-solar disks, accretion disks, and spiral galaxies?

- Ready for mission start: 2006-2007
- Aerocapture into close Saturn orbit
- Co-rotating, "hovering" orbit approx. 3 km above ring plane
- 30 days in close ring orbit

- **Key Capabilities**

- Aerocapture
- Advanced propulsion: SEP or solar sail
- Low mass, high-efficiency chemical propulsion
- Autonomous navigation and maneuvers





Recommended Missions



*Near-term and Mid-term**
(2003-2007) (2008-2013)

Far-term
(2013 and beyond)

Mars Exploration Program

(Continuing)



Mars Sample
Handling and Analysis
Mars Subsurface Exploration
Mars Robotic Outposts
Earth-Mars Internet

Intensive site exploration
Advanced outposts
Deep coring and search for extant life

Outer Planets Program

(Continuing)

Europa Lander
Titan Explorer
Neptune Orbiter/Triton Flybys

Robotic outposts and sample returns
Kuiper Belt exploration
Interstellar precursors

Discovery Program

(Continuing)

Competitively Selected Missions

Advanced Studies of Planet
Formation and Evolution

To Build a Planet (Proposed new program)

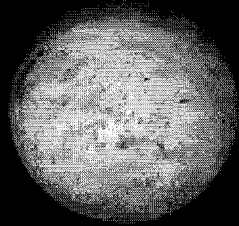


Comet Nucleus
Sample Return
Venus Sample Return
Saturn Ring Observer

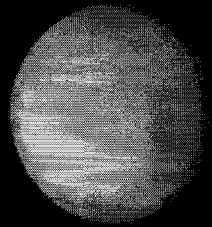
Sample all types of bodies
Deep atmospheric probes
Explore large asteroids/protoplanets

* Approximate mission start dates

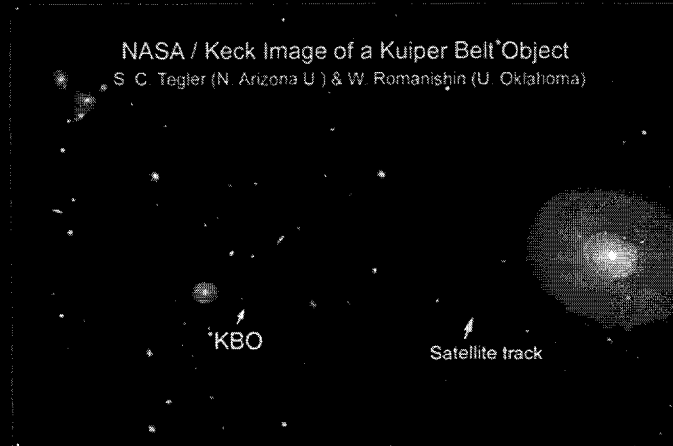
Exploring Organic-Rich Environments: Future Concepts



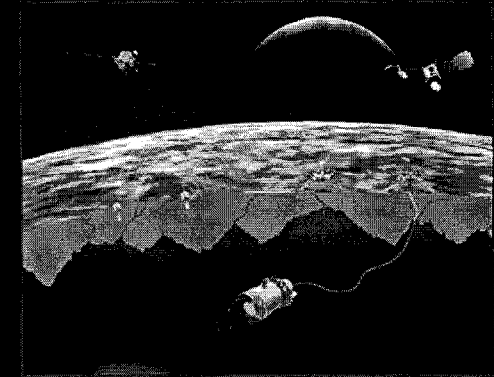
Triton Lander



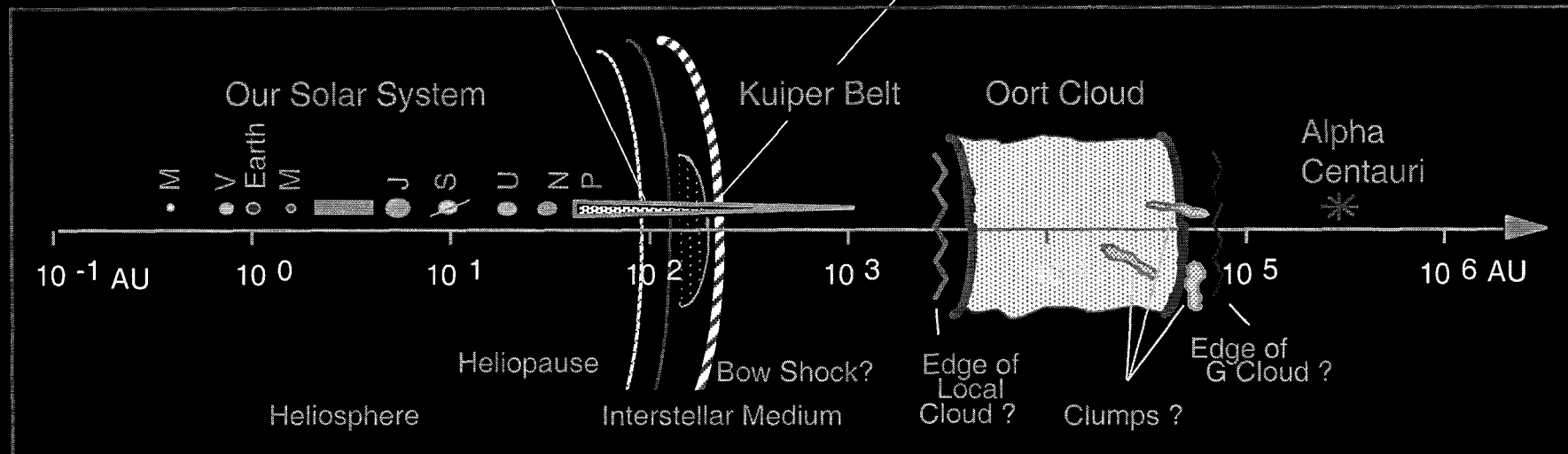
**Outer Planet
Satellite Sample Returns**



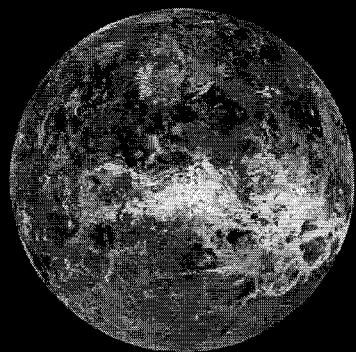
**The Kuiper Belt and
Interstellar Exploration**



**Europa Ocean
Science Station**

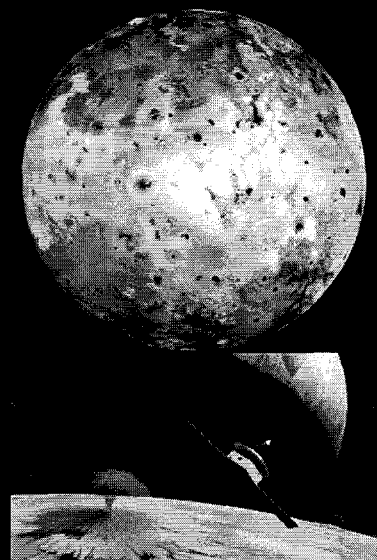


To Build a Planet: Future Concepts

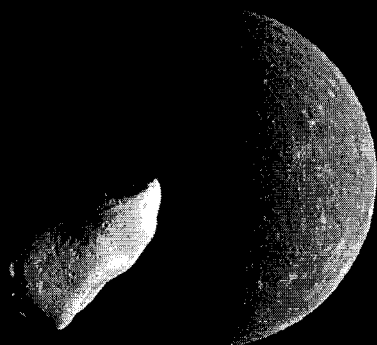


Monitor planetary
climate change:
Venus Robotic Outposts

*Future missions will focus on the
detailed exploration of harsh
planetary environments and on
the return to Earth of samples
from all types of bodies*



Observe active
geological processes:
Io Volcanic Observer



Return samples from throughout
the solar system

